

LCA Surveys

LCA Experiences in Danish Industry

Results of a Survey

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Abstract

A study has been performed on Danish industry's experiences with LCA. Twenty-six enterprises from different sectors completed a questionnaire. The enterprises are still in an adoption and learning phase, and experiences with full-blown LCA's are sparse. Expectations of future market pressure to supply more environmentally friendly products is the most important incentive for the enterprises to engage in LCA activities. This pressure, however, has not yet emerged and the enterprises have not achieved the expected competitive advantages. LCA work has revealed new environmental aspects of the products with subsequent new priorities in the environmental efforts. Only a few enterprises have built up in-house LCA competence, whereas consultants are heavily involved in LCA work. In large enterprises, LCA work is predominantly carried out by environmental staff members, but the product development staff is also involved. The nature of the co-operation and distribution of roles between these two actors is not clear, and should therefore be studied further.

Keywords: Cleaner technologies; consultants; LCA methods; Life Cycle Assessment; motivation; organisation; product development; product-oriented environmental policy; survey; working environment

projects have been initiated. Several of these projects are aiming at streamlining the LCA methods so that small and medium-sized enterprises could make most of them. Finally, on their own initiative, some enterprises have carried out an LCA of one or more products, typically in order to use these results for marketing.

To get an overview of the LCA experiences in Danish industry, a survey based on questionnaires was carried out (BROBERG et al., 1998). The main questions to be investigated were the following: What are the motivations of the enterprises to engage in LCA work? How thorough and comprehensive is the LCA work? What expectations did the enterprises have to the LCA and were they fulfilled? In what way and by which methods and means is the LCA work organised and performed? What kind of measures are necessary to promote the use of LCA in Danish industry?

The discussion will compare our results with those of similar surveys. Sullivan & Ehrenfeld (1992) investigated the use of LCA in twenty-six manufacturing enterprises in the United States. Grotz & Scholl (1996) made a similar survey of German enterprises. The use of LCA in Swedish industry was investigated by Baumann (1996). Finally, in a European-wide survey of twenty-five enterprises, Olsen (1997) has been focusing on the chemical industry. Although all the surveys are based on questionnaires, the methodologies are quite different. Hence, a comparison should be viewed with caution.

1 Introduction

Life cycle assessment (LCA) is increasingly relevant to Danish industry. Since the mid-1980s environmental policy has been focusing on the implementation of cleaner technologies and later on stimulating the implementation of environmental management. Recently, the focus of environmental policy, however, has been changing towards a product-oriented policy where eco-labelling, public procurement and stakeholder management are crucial elements (Danish EPA, 1996) so that LCA will become an important tool. Since the early 1990's, Denmark has made substantial efforts to develop LCA tools. In the period 1991-1995, the EDIP (Environmental Design of Industrial Products) project concurrently developed methods and tools, and tested them in five industrial enterprises (WENZEL et al., 1997). Beside these experiences several small, publicly-financed life cycle

2 Methods

The identification of relevant enterprises was made through contact with the twenty-five members of an LCA working committee set up by the Danish Environmental Protection Agency. The members are experts from leading consulting firms, universities, industrial bodies, and the Danish EPA. Through this procedure, thirty-nine enterprises were identified for having some sort of LCA experience. We consider this number to include 90-100 percent of Danish enterprises having LCA experiences at that time. The thirty-nine enterprises were contacted and asked to participate in a survey. Twenty-eight enterprises were willing to participate in the survey and a questionnaire was sent to an appointed contact person. Twenty-six enterprises completed the question-

naire in all. The questionnaire included sixty-one questions, with a few exceptions all close-ended. The results of the questionnaire were encoded into the statistical data processing programme of SPSS. The survey was made in the period from October 1997 to February 1998.

2.1 Characteristics of the respondents

The enterprises that took part in the survey represented the following industrial sectors:

Industrial sectors	Numbers
Electronics and mechanical engineering	6
Other manufacturing	5
Furniture industry	4
Industrial and public services	3
Chemical industry	2
Pharmaceuticals	2
Printing industry	2
Textile industry	1
Food industry	1

The sizes of the enterprises varied from seven employees to more than ten thousand. Ten enterprises were certified according to the ISO 14001 or registered in the EMAS scheme. All the enterprises had previously been engaged in work with cleaner technologies. Half the enterprises (13) participated in various publicly funded projects on development and testing of methods for life cycle assessment, whereas the rest defrayed the expenses themselves. The contact persons filling in the questionnaires were environmental staff members (16), R&D managers (5), one quality manager, and one technology manager. Three contact persons did not inform of their position.

3 Results of the Survey

3.1 The incentives to engage in LCA work

The enterprises have had quite different incentives to start carrying out LCA. But as it appears from Figure 1, the wish to be in the forefront was among the most important motivating factors. The enterprises seem to expect a substantial marketing and image advantage from the LCA work. Also,

demands from market and customers seem to play a role. But they do not expect authorities to enter into the field with demands, neither now nor in the future. Neither did the enterprises expect an increased pressure through eco-labelling. This is no doubt due to the fact that eco-labelling has been a long time on its way. So far the EU eco-labelling scheme has been progressing extremely slowly. The Nordic Swan-labelling has recently been valid in Denmark but may require a longer period to become substantially incentive. In addition, the enterprises did not expect to profit by the LCA work. This is in line with the fact that the enterprises do not believe that the LCA work will contribute to their environmental management. In other terms, the enterprises regard the LCA work as an isolated activity with relation to the environmental profile of the product and the image of the enterprise in the market. Thus, the LCA work is not regarded as a basis for the general environmental work in the enterprise in relation to the production. The two most important goals enterprises intended to achieve by the LCA work are reported to be an identification of the environmental profile of existing products (69%), and establishing a basis for product development (65%). In a multiple marking scheme the goals following these two were: Improved dialogue with customers and/or suppliers (50%), marketing (46%), basis for eco-labelling (31%), contribution to environmental reporting (31%). The least important goals are LCA as a basis for procurement and for choosing between suppliers (27%), and as a basis for environmental management (27%). Again this stresses a weak contact to the environmental management systems.

3.2 How thorough and comprehensive is the LCA work?

Ten percent of the enterprises indicate that they have had "comprehensive" LCA-experience, 70 percent that they have had "some", and 20 percent state that they have had "limited" experience. Only a third of the enterprises have been performing LCA for more than three years. The number of life cycle assessments that have been carried through differs. Eleven enterprises have only made an LCA of one product or process, but yet there are eleven enterprises that have

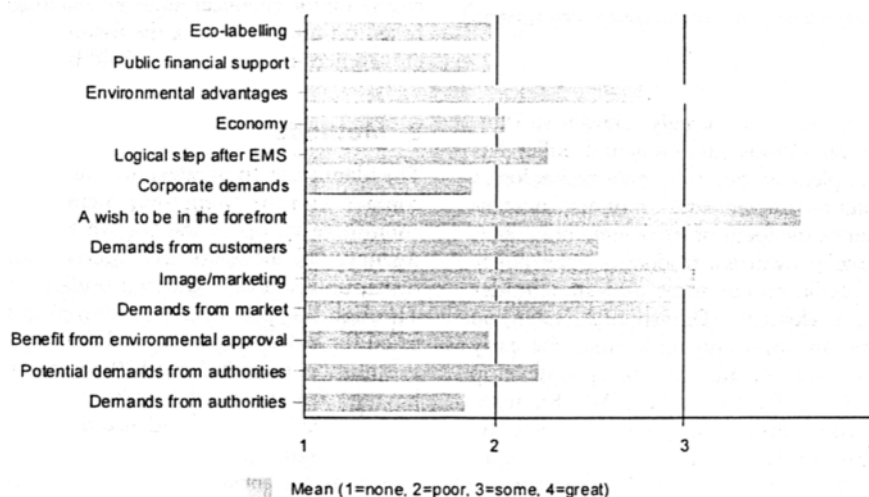


Fig. 1: The enterprises' incentives to engage in LCA work (n = 26). Every position has been ranked. EMS = Environmental management system

Table 1: The number of years during which the enterprises have undertaken LCA and the number of products assessed (n = 26)

	Number of products assessed				Total
	1	2	3	More than 3	
Less than 1 year	6				6
1 to 3 years	4	2	1	3	10
More than 3 years	1	1		8	10

Table 2: The period during which LCA was performed and how thoroughly it was performed (n = 23)

	Depth of LCA work			Total
	Life cycle thinking	LCA screening	Thorough LCA	
Less than 1 year	3	2		5
1 to 3 years	5	3	2	10
More than 3 years	1	2	5	8

made LCA studies of more than three products. As it appears from Table 1 there is a clear connection between the length of the period during which life cycle assessments have been performed and the number of products assessed. The longer the time, the more LCAs. Those who started more than three years ago have consequently kept interest in and have tested the method on still more products and processes.

The depth of the LCA studies performed in the enterprises are quite different. Thirty percent of the enterprises state that they have applied a "thorough" LCA, 30 percent state that they have made a "screening", and 40 percent performed "life cycle thinking" activities. Again there is a connection to the period during which the enterprise has been using LCA. The longer the enterprise has used LCA, the more thoroughly it was performed (→ Table 2).

3.3 Results of the LCA work

In general the enterprises' experiences with LCA are positive. Almost half of the enterprises (11) stated that their LCA work had revealed new environmental aspects of their products that they had not realised before. It is typically a question of the enterprises becoming aware of different weighting between the life cycle phases, e.g. manufacturing paper is a considerably heavier environmental load than the printing process, or environmental effects that have not been observed before they appear in the course of the life cycle, e.g. that the methane formation by depositing in some cases can contribute significantly to the green house effect. Beside the fact that the enterprises have learnt something new, the LCA work has also influenced the priorities of the environmental efforts in the enterprises. In all, 70 percent of the enterprises state that the work on LCA has actually resulted in new priorities. It is generally the case that energy consumption and transport have come more into focus in many enterprises. The efforts of the enterprises to change in products and processes has concentrated on savings of materials and subsidiary materials/chemicals. But also the substitution of materials and subsidiary materials/chemicals are made, which is similar to our experience from enterprises' work on environmental management and

cleaner technologies (CHRISTENSEN et al., 1997). In "ordinary" enterprises, the savings of resources (good house-keeping) is a method that is used more frequently than substitution, but the more the enterprises engage in environmental questions, the more they choose substitution and more radical cleaner technology solutions.

In general, we can conclude that the enterprises have had good experiences with their LCA work. Eighteen of the twenty-six enterprises also intended to base their future product development on LCA studies. Ten of those stated that the LCA results would be included in the decision processes with "great" or "very great" weight. Six enterprises stated that LCA would not be involved in future product development. Surprisingly, three of those enterprises belong to the group that have made thorough LCAs. Our study offers no explanation for that. In spite of the good experiences it does not necessarily mean that environmental assessment will be the cornerstone of product development. Table 3 shows the priorities in product development as ranked by the enterprises. Quality, function and price continues to be most important, and the significance of environmental assessment in product development only just surpasses the time of delivery. In a dynamic view, what seems to be achieved is that environmental assessment has become a legitimate activity that has entered the arena of product development.

Table 3: Ranking of parameters in product development in a 1 to 4 scale (1 = lowest ranking, 4 = highest ranking) (n = 20)

Parameter	Mean
Quality and function	3.7
Price	2.7
Environmental properties	1.7
Time of delivery	1.6

Figure 2 shows how the experienced advantages gained by the enterprises from the LCA work relate to their expectations of the LCA activity. A clear picture appears showing that the enterprises was expecting definite competitive advantages and a better image. To a certain extent they have developed a better image, but competitive advantages seem to have failed to appear. This is a clear indication that the pressure from the market has not yet appeared. One reason is that the product-oriented environmental policy has not yet been put into practice. When asked what is needed to promote the use of LCA in Denmark the enterprises point to stronger demands from the customers (mean = 2.83 in a 1 to 3 rating scale), to eco-labelling (2.52), and green public procurement (2.35). Many stress the importance of subsidy schemes (2.36), probably realising that pressure from the market does not suffice in the present situation. So the enterprises most certainly wish that the elements of the new product oriented environmental policy, market orientation, green procurement and stakeholder involvement will function as soon as possible.

3.4 Initiating and organising the LCA work

Who initiates the LCA work? The study proves that the environmental department (reported by 50% in a multiple marking scheme) or top management (30%) take the initia-

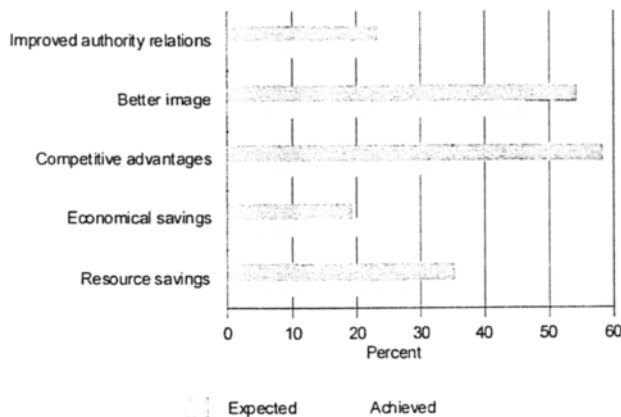


Fig. 2: Expected and achieved results of the LCA work (n = 26). Multiple marking offered

tive. It is more unusual for sales and marketing (20%) or R&D (20%) to be initiators. In the large enterprises with more than 500 employees it is almost exclusively the environmental department that initiates the work. In small enterprises top management is the most frequent initiator. Consultants play a modest role as initiators of LCA work (< 10%). This may reflect the fact that the consultants do not have ready-made "products" behind the counter to sell to the enterprises.

The LCA work is frequently organised in formal "project groups" (50%). Work formalised in this way is more usual in the large enterprises (> 75%) than in the small and medium-sized enterprises (< 30%). Figure 3 shows the affiliation of the participants in the LCA work. The employees participating in the LCA work most frequently come from the environmental department, but the development department, and sales and marketing are also quite well represented. But this study cannot reveal to what extent really cross-functional project teams are formed and working. Also, more detailed studies are necessary to reveal how well LCA work is rooted in the R&D or product development departments. Preliminary data suggest that LCA work is predominantly rooted in the environmental departments or persons. The co-operation and dis-



Fig. 3: The organisational affiliation of the employees in the LCA work in the enterprises (n = 26). Multiple marking offered

tribution of roles between environmental and technical staff members also need to be studied further. This is also of importance as most of the questionnaires in our study are completed by environmental staff members.

The consumption of man hours in the LCA work varies significantly, from 10 hours all the way up to 4,000 hours with an internal average consumption of 650 hours. The large enterprises generally spend more time on LCA work than the small and medium-sized ones. The vast majority of the enterprises use consultants. Only three of the twenty-six enterprises have managed without. The use of consultants varies from 50 hours to 1,500 hours with an average of 450 hours. The ratio of consultant hours and enterprises' own resources varies essentially depending on what type of life cycle assessment they have carried out (→ Fig. 4). The enterprises stating they have made a thorough LCA in average spend 1,800 in-house hours and 500 hours for consultants. The enterprises stating they have made screenings have a somewhat smaller consumption equally divided between internal and external costs. Enterprises at the life-cycle-thinking level have used the smallest number of hours and most of these were spent on consultants. In general, consultants take part in four main activities: goal definition and scoping, data collection, calculations, and reporting, whereas the enterprises mainly take part in the first two activities.

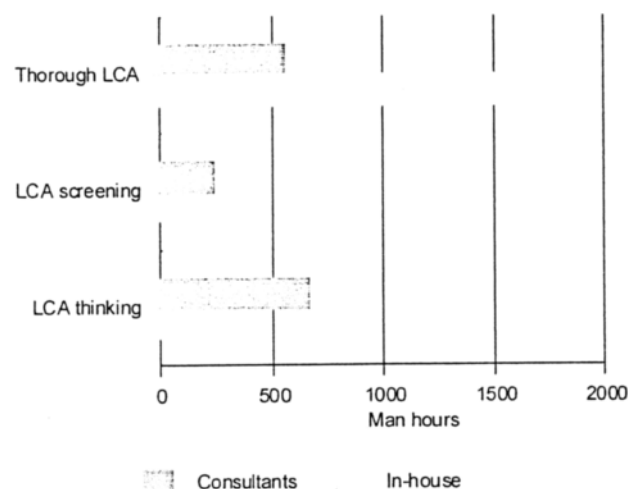


Fig. 4: The average consumption of man hours, in-house and for consultants, depending on the thoroughness of the LCA

3.5 LCA methodology

The methodological approaches to work on life cycle assessment can differ considerably. Most of the enterprises have used the Danish EDIP method (WENZEL et al., 1997). Twenty of the enterprises used this method, whereas only a minority refers to SETAC (CONSOLI et al., 1993) or Nordic Guidelines (LINDFORS et al., 1995) as their point of departure. ISO 14040 is mentioned only by two enterprises, which is hardly surprising, considering how new this standard was at the time of our study.

The life cycle assessments performed by the enterprises include most of the phases from extraction of raw materials to disposal/recycling. The production process of the enter-

prise itself, however, is the most frequently included. Certain life cycle phases may be left out because they are not affected by design changes of the product.

Twenty-five enterprises reported to have carried out an impact assessment. The different impact categories of an LCA are not included equally often. Resource consumption, acidification, and the green house effect are the most frequently used categories (\rightarrow Fig. 5). This may indicate that the consumption of fossil fuel, e.g. concerning transport, is a recurrent theme of many life cycle assessments. Working environment is the category most frequently excluded. This may be due to the fact that this impact category is the most difficult to make a stringent methodological approach to. The lack of an international consensus whether it should be included in life cycle assessments at all may play a role. On the other hand, more than half of the enterprises think that working environment should be included, most frequently as chemical and physical impacts, whereas there is considerable doubt whether to include psycho-social impacts.

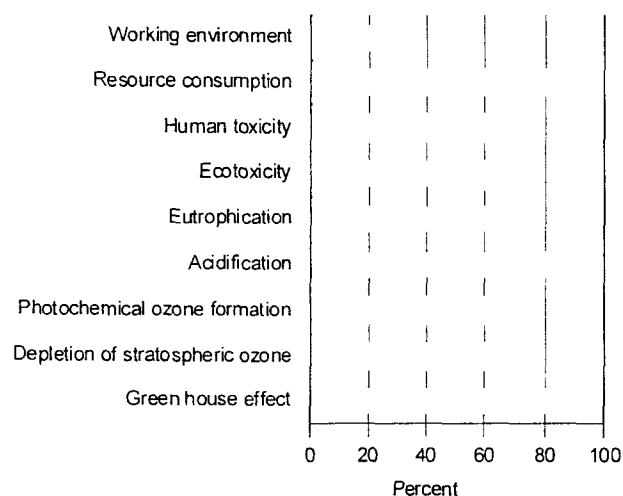


Fig. 5: The frequency of various impact categories in the LCA studies ($n = 26$). Multiple marking offered

Three-fourths of the enterprises allocated the environmental impacts to various products/subsidiary products. In 75 percent of these cases the allocation is based on technical criteria, and in the remaining 25 percent it is based on economic criteria. More than half the enterprises (58%) made a valuation between the various potential effects. The calculations to be made in the life cycle assessment are most frequently made by means of an LCA software programme or a spreadsheet (90%). One enterprise made the calculations by hand. More than half of the enterprises used EDIP's software programme (EDIP-Tools).

4 Discussion and Conclusions

This survey supports the findings by SULLIVAN & EHRENFELD (1992) indicating that companies engage in LCA work to benefit from strategic and marketing opportunities by being at the forefront. According to OLSEN (1997) the situation is different in the chemical industry. The LCA work in

chemical companies seems rather to be driven by demands from customers. This defensive attitude is reflected in the fact that "aware raising" is considered the most important application of LCA. BERKHOUT (1996) suggests the position of the chemical industry in the product life cycle as an explanation. They often face the customers' demand for life cycle inventory data.

In line with BAUMANN (1996) and GROTZ & SCHOLL (1996) this survey finds that LCAs are rarely used in procurement and as a basis for choosing between suppliers. And, in line with SULLIVAN & EHRENFELD, we find that LCA work is not integrated into other company programmes. The LCA work surprisingly seems not to form part of the environmental management systems. The consultants role differ significantly in Danish industry as compared with that in the Swedish and German industry. In their surveys BAUMANN as well as GROTZ & SCHOLL demonstrate that LCA work is mainly an in-house job whereas consultants are used extensively in Danish LCA-active companies. This may suggest that Danish enterprises are still in an adoption and learning phase. It may also reflect the fact that Danish enterprises are small and medium sized in general without substantially environmental staff resources.

Our survey finds it significant that in-house LCA work is most frequently carried out by an environmental department and then by R&D or product development. In Swedish industry, R&D or product development is by far the place where LCAs are carried out (BAUMANN, 1996). Despite indications of cross-functional teams LCA work in Danish industry seems not to be deeply rooted in technical departments. The co-operation and distribution of roles between the environmental and technical staff, however, are not revealed by our study.

Whether, or to what extent, LCA work will be 'internalised' in Danish enterprises is still an open question. Internalisation will require new in-house skills and competences. So enterprises may choose to subcontract life cycle studies to outside consultants (BERKHOUT, 1996). What will happen depends on the market pressure. If the product oriented environmental policy succeeds and a market driven environmental dynamics in production chains evolves, a lot more enterprises may be forced to adopt LCA as a management tool.

In conclusion, the survey proves that experiences with LCA work in Danish industry continue to be sparse. Industry still is in an adoption and learning phase. The pioneering enterprises have engaged in LCA work mostly to be in the forefront, thereby hoping to profit from being the first to market environmentally friendly products. For most enterprises, however, this hope has not been realised. Some of the front runners have thoroughly tested the LCA methodology. Almost half the enterprises think that the LCA work has uncovered environmental aspects of their products they did not know of before and it has resulted in new priorities in their environmental efforts. Consequently, more than two-thirds aim to include LCAs in future product development. So many of the enterprises are prepared to meet the challenges that future market-based and product-oriented environmental policy will bring.

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State-of-Art: LCA in the Nordic Region

Status of Life Cycle Assessment (LCA) Activities in the Nordic Region

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Abstract

The status of Life Cycle Assessment (LCA) activities in the Nordic Region (period 1995-97) is presented, based on more than 350 reported studies from industrial companies and research institutes in Sweden, Denmark, Norway, and Finland. A large number of industrial sectors is represented, with car components, building materials, pulp and paper products, electronic components and packaging as the most important ones. All aspects of LCA methodology are used: 90% use impact assessment, 80% impact assessment and valuation step. In most studies, more than one valuation method is used for ranking environmental impacts.

LCA studies are well integrated in the business activities in

many large Nordic corporations. From the early attempts, more familiar with LCA methodology, LCA has been integrated in strategy development, product development, process development and, to some extent, marketing. LCA has not only been used in the strict sense presented in the ISO 14040-43 standards. The systems approach, which is the basis for LCA, has also been modified and used in Sustainable Product Development, and in Environmental Performance Indicator and Product Declarations development. Future applications should be within Environmental Impact Assessments.

Keywords: Applications; industrial sectors; LCA software systems; Life Cycle Assessment (LCA); methodology; nordic region; status report